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A REGIONAL LAND USE SURVEY

BASED ON REMOTE SENSING

AND OTHER DATA

Ends? yes
Prin. Invest.?

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2480 W. 26th Avenue
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10 January 1976

QUARTERLY REPORT FOR PERIOD OCTOBER 10 - JANUARY 10, 1976

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16. Abstract

During this third quarter of the 18-month project, the completed training site data from the 24 7½-minute quadrangles within each state was fed into the new pattern recognition program. Some states had added land use/cover categories in addition to the basic 19 classes and had provided seasonal data to improve the discrimination statistics. The technical subcontractor, Colorado State University, substantially reprogrammed the computer programs for pattern recognition. The Federation convened two state work sessions on this project and began distribution of the Users' Manual for compiling a multi-source land use information system in cellular form and incorporating the Landsat cellular map output. Plans were made for a second project review meeting.

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PREFACE

Objectives: To test and apply Landsat, other remote sensing and ground data, in an optimum mix for seasonal land use survey, for portions of six states in the region (Montana, Wyoming, Colorado, New Mexico, Utah, Arizona). Specifically: (1) to encourage interstate cooperation in the utilization of earth resources satellite technology for solving land use planning problems; (2) to discuss and work toward the development of compatible interagency, interstate information system procedures; (3) to adopt and test a common land use classification; (4) to evaluate the efficiency of a land use information system, utilizing satellite and other data; and (5) to provide a medium for information exchange concerning remote sensing and geo-information systems.

Scope of Work: This Quarter's work (October 10 to January 10) is following the Work Plan of January, 1975. The Schedule and Time Sequence following Page 14 of that work plan is here used as reference. The states of Montana, Wyoming, Colorado, New Mexico, Arizona, and Utah have appointed official lead agencies, and they in turn have interagency contacts. With the assistance of the Federation and its subcontractor, these groups are beginning to develop state land use information systems to utilize satellite, other remote sensing and conventional data. This project has adopted a detailed working scale of 1:24,000, and a grid cell size of 1.15 acres which is exactly in conformance with the Landsat picture elements and the USGS 7½-minute quadrangle mapping system. In addition to the Landsat source, other data from imagery and ground surveys will be utilized in the test quadrangles for demonstrating multi-source map compositing and associated quantitative analysis.

Conclusions: This is the third quarterly report, offering an interim account of the feasibility and problems of this procedure.

In order to improve interagency coordination within states, there is a need for (1) more display material and (2) state lead agency initiative in identifying the prototype resource management problems in the quadrangles. Six Federation of Rocky Mountain States state meetings have been helpful in encouraging interagency participation.

On the technical side, the project is (1) streamlining the computer process for pattern recognition for an extensive data system, with 24 target quadrangles and hundreds of ground truth sites being mapped through several seasons; (2) the project is hearing the implementation of cellular mapping and compositing to blend Landsat plus other sources of physical, social, and economic area data. These technical possibilities will be performed or defined in the final reporting phase of this project, looking at the feasibility of a wide-spread regional, state, or interstate land use information operations.

A second review meeting is planned for January 13 and 14 in Denver, Colorado.

INTRODUCTION

This is the third quarterly report in the 18-month scheduled project.

The project scope is complex and must be described in parallel roles of six state lead agencies, a technical contractor for extracting land use information from Landsat digital tapes, Los Alamos lab's preparation for computer mapping and analysis, and the Federation as coordinator and demonstrator of multi-source and multi-purpose information procedure.

This summary refers to activities scheduled for this period in the Work Schedule and Calendar of the original Work Plan, January, 1975.

Task II.B - Check the states' selected training sites, relative to land use categories and the problems of signature analysis--substantially completed, some work continues.

Task II.C - Analyze effects of extraneous local variables on the interpretation of land use classes - underway.

Task II.D - This task implemented by bilateral conferences between FRMS, subcontractor, and individual states - held in two additional states. (A complete review session is scheduled for January 13, 14.)

Task II.E - Determination of final cell size - completed.

Task II.F - Selection of socio-economic and resource topics for combination with Landsat data - underway.

Task II.H - Correct the signatures for selected training sites - complete.

Task II.I - Completed

Task III.A - Completed

Task III.B - Aggregate pixels into larger cellular mapping units - not needed; will use pixel size cells.

Task III.C - Los Alamos Scientific Laboratory cooperation on cell aggregation procedures - changed to cell mapping technical methods, underway.

Task III.D - Second field surveys, as needed, for training data - ongoing in one state.

Task IV.D - Comparison of Landsat process with other extensive area coverage - begun in some states.

All needed Landsat products are in hand--selected seasonal imagery CCT's, prints, and microfilm. However, the U-2 high altitude color infrared coverage was deficient in terms of: (1) too late for scheduled mid-1975 ground truth work, and (2) glare and burnout portions of images in level lands, and (3) images lying off the published flight lines (FSR flight lines).

During the third quarter, the six states completed all the required training site field work, identifying "pure types" of each basic land use category. Each training site contained thirty acres or more. In some cases of difficult signature analysis, such as urban, residential and/or certain crops, training site information included information on proportions of different elements, by season. An annual crop history might include approximate date of ground preparations, peak growth, and harvest. This involved checking back for the 1974 and 1973 uses of the field, since the investigation was conducted during 1975. Landsat imagery by seasons is distributed mainly in the calendar year 1974.

DATES OF SELECTED SEASONAL IMAGERY (LANDSAT SCENES)

1974 Landsat CCT's Selected for Seasonal Coverage and Minimum Clouds:

Arizona (four seasons)
February 14, 1974
May 15, 1974
August 31, 1974
November 29, 1974

Colorado (three seasons)
May 30, 1974
August 10, 1974
November 26, 1974

New Mexico (three seasons)
May 17, 1974
August 10, 1974
November 26, 1974

Montana (four seasons)
June 1, 1974
July 25, 1974
September 17, 1974
November 10, 1974

Wyoming (same dates as Montana)

Utah (three seasons)
June 22, 1974
August 15, 1974
October 8, 1974

The reasons for this retrospective schedule were to provide optimal imagery for known field conditions by seasons; and to have the entire cycle of imagery in hand for machine processing.

It has proven feasible to use the 1.15 acre cell size (instead of the 2.5 cell size suggested in the first Quarterly Report. The subcontractor, Colorado State University, was able to perform thematic analysis at this cell size, using new pattern recognition routines.

Progress in Processing of Computer Compatible Tapes

Landsat imagery for one test quadrangle (USGS 7½-minute quad at a scale of 1:24,000) in each state is being processed by the subcontractor, Colorado State University.

Of special importance was the streamlining of the computer program for the CCT conversion into land use maps. The CSU remote sensing scientists resolved a number of problems inherent in their original pattern recognition program. That program, called RECOG, had been derived from the Purdue and Michigan programs, but required seven separate phases of processing Landsat digital data. It was designed for Landsat image analysis extensively over large scenes. The new Landsat Mapping System (now called LMS) is compressed, lower in cost, and able to focus on partial areas of the Landsat scenes, by simple NW corner reference points, and dimensions of the small rectangle.

The cost effectiveness of this new process is indicated, for example by a saving in computer time for the same results--from a previous 800 seconds of CPU time for processing a Landsat scene to 30 seconds in the new LMS program. (See New Technology.)

Progress of the Computer Mapping and Compositing System

Each state will apply multi-topic mapping (compositing) in one or several quadrangles for an appropriate demonstration of planning and management solutions. Los Alamos laboratory will conduct the computer analytics, using the below described CMS-II or a similar program.

The computer mapping system (CMS-II) being developed and distributed by FRMS is capable of storing and manipulating the cell values through various mathematical, statistical, and logical subroutines and aggregating any cells into larger cells for scale changing.

Each potential user or functional area, i.e., agriculture, natural resources, etc., needs its own particular classification of land uses an conditions. The technical problems of using a multi-purpose land use system are substantially aided by CMS-II. While remote sensing can generally "see" only elementary indicators of certain kinds, it is equally important to use all other available sources--aerial photography,

geological data, water data, industrial and urban data, etc. Through CMS-II, all such data may be mapped in digital cells and combined into functional or activity maps of various kinds; for example, "Forest Grazing Area," "Open Pit and Strip Mining," "Parks and Recreation Areas," "Timber and Recreation" descriptions, thus enhancing the sensitivity of the entire areal data file. The project aims an optimal mix of (1) satellite remote sensing and (2) efficient blending of other data.

The CMS-II program will now operate on IBM hardware, as well as UNIVAC and CDC. The basic features of the new CMS-II cellular mapping program are:

1. Small memory core requirements to reduce operating costs.
2. Compatible with the Landsat cellular output format.
3. Compatible with any other cellular mapping program, such as SYMAP, for receiving smoothly interpolated cell maps based upon random field data samples.
4. Will accept both digitized polygonal input from other digitized mapping tapes, conventional maps, or tabular data.
5. Will accept any data tables for mapping via a Master Map and Dictionary of the pattern of survey areas.
6. Internal storage of maps (map-filing).
7. Instant symbol conversion from one data scale to another.
8. Inter-map arithmetic compositing through addition, subtraction, multiplication, or division point-to-point, map-to-map.
9. Inter-map logical compositing, using logic functions.
10. Scaling and mapping of census data from tabular files.
11. Frequency distribution or histogram output.
12. Compatability with correlation or Multiple Regression programs, which may manipulate the cellular map file.
13. Aggregation of small cells into larger for statistical or scale changing purposes.

Utah Workshop of December 20, 1975

Scope: This was the second session in Utah to discuss user participation in this project and to review progress to date. Most discussion centered on further analyses to be conducted, combining additional multi-source data with Landsat land use information. Results of this visit were:

1. Color infrared (U-2) film received from EROS was deficient in several ways.

2. All training site work has been completed.

3. A new analytic phase is beginning, to be followed up by the Utah lead agency.
   a. Each target area will have one state or local agency planner, plus a University assistant to define realistic resource management problems and to implement the multi-source data compilation and analysis.

   b. Example: Joe Moore defined a "land valuation change" problem in the Farmington quad, for multi-regression explanation using the following variables:

      Highway Accessability
      Utility Accessability
      Aspect and View
      Proximity to Existing Housing or Industry of given quality
      Proximity to Salt Lake City
      Present Relative Value of Land
      Specific Land Use Proposed or Zoned

   c. Crandall was interested in the 1-acre cellular mapping of land uses, and the capacity to receive much data already collected on a discontinuous basis in other categories for the entire Wasatch front.

   d. Carlson was interested in starting the cellular mapping and modelling process in the Southwestern part of the state in the active coal strip mining region, as soon as possible.

   e. Oakey and Weaver were interested in linking the map modelling process with their UPLAND Project which allocates industrial, labor force, and broad land use development to counties and census county divisions in some areas.

   f. Rowley was interested in the Farmington quadrangle for the mapping and modelling of lake and vegetation types, in connection with waterfowl habitat and populations.

   g. Ridd indicated that he would organize the planning teams for each quadrangle, try to outline their analytic approaches to each quadrangle for the FRMS meeting January 13, 14.

Utah Workshop (Cont'd.)

Respresenatives Present:

Dr. Merrill Ridd, Lead Agency Representative
Burton Carlson, State Planning Coordinator
Joe Moore, Davis County Planning Director
Mick Crandall, Wasatch Regional Council of Governments
David Conine, State Planner
Ed Rowley, State Department of Wildlife
Chauncey Palace, State Planning
Gary Rockwood, DURA Business Research
Morris Johnston, University and Private Planning
Owen Burnham, Local Planning in Kaiparowitz Area
Jack Oakey, State Planning
Roger Weaver, State Planning
George Nez, FRMS

Montana Workshop of January 9, 1976

Scope: This was the first potential user and interagency work session in Montana. Nineteen persons attended as shown below. The items covered and questions discussed are listed below and will be followed up by the state lead agency:

1. Review of Montana state activities to date in selecting and field surveying training sites for multi-spectral signature calibration and a project overview.

2. Multi-source data combinations in the test quadrangles, using Landsat input plus numerous types of agency data, were discussed.

3. Suggested specific analysis possibilities in Montana's quadrangles were:

   a. Decker quadrangle and Colstrip quadrangle southeast, both heavy stripmining and stripmineable areas with dynamic impacts upon agriculture and water.

   b. Beaver Creek quadrangle and Poker Jim Butte quadrangle, both stable agriculture, grazing, and forest zones, having multiple-use planning questions.

4. Cooperative interagency approach to the project might be undertaken by the lead agency.

5. State responsibility for project evaluation and suggested essential criteria.

6. Questions came up concerning the Landsat Digital Land Use Identification, Multi-Spectral Signatures, and how ground truth from the training sites substantially control the Landsat categorical mapping. There was initial confusion about the conventional "activity classifications" versus the objective multi-spectral readings of selected training sites. The discussion clarified how the Landsat multi-spectral target categories may have to differ from conventional "activity categories," because of the constraints of multi-spectral scanning.

7. Questions were raised about the efficiency of cellularizing other data sources--from aerial color infrared to conventional ground survey data. Recent Montana efforts were described, involving mechanical scanning and gridding efforts which produced color and grey scale outputs.

8. The discussion cleared confusion concerning the difference between primary sensing the earth's surface (by Landsat) and the use of other data sources.

9. Other analytic possibilities in the Decker and Colstrip Southeast quadrangles include multi-source compositing of principal land uses and indicators of potential expansion in:

   A. Coal stripmining, which may reveal imminent "competition zones." (A similar analysis of land use conflict zones was conducted in Wyoming by FRMS, using one-mile cells.)

   B. Highway planning, route selection--possible application of remote sensing and other source cellular mapping for strategic studies of transportation corridors.

   C. Forest service--possibility of using LANDSAT for distinctions between types of timber for timber inventory.

   D. Mining areas--here the existing data resolution plus underground data for operational management already exceeded the capabilities of remote sensing. The only possible useful application of remote sensing might be in reconnaissance of extensive areas together with other data via cellular mapping and compositing to indicate imminent use and water use competition involving mining.

Indicated Next Steps for the Montana Lead Agency:

1. Verification of accuracy of the Landsat mapping of land uses from the given training site data.

2. Formulation of practical problems of analysis or development simulation in several of the quadrangles--for exercising the Landsat and other sources of land use and operational data.

Representatives Present:

Albert C. Tsao, Department of Natural Resources
George Cawlfield, Department of Natural Resources
Gary Fritz, Department of Natural Resources
Dennis Hammer, Department of State Lands
Mike Woods, Department of State Lands
Joe Murphy, Department of State Lands
Larry Pointer, Bureau of Land Management
Lloyd F. Emmons, Bureau of Land Management, State Office, Billings
Susan Boyle, Forest Service
Dick Howell, Department of Highways
Charles Van Hook, Department of State Lands
Liter Sperre, Department of Fish and Game
Jack Schmidt, Department of State Lands
Dick Juntunen, Department of State Lands
Gary Rogers, Department of Community Affairs
Tom Dundas, Research & Information Systems, DCA
Dana Glatz, Department of Community Affairs
Doug Mutter; George Nez, FRMS

FINAL SELECTED MAPPING QUADRANGLES IN EACH STATE

Within the large interstate test sites of the project, selected 7½-minute quadrangles for full mapping of land uses and land cover have now been finally established, as shown below. These involve only a few shifts from the quadrangles shown in the previous Quarterly Report.

COLORADO TEST SITE AND QUADRANGLES

1. Alamosa W. Urban, irrigated agriculture, pasture, recreation.
2. Manassa. Irrigated, range, recreation.
3. Fox Creek. Forest, grass, range, recreation.
4. Zapata Ranch. Forest, grasslands, range, sand dunes.

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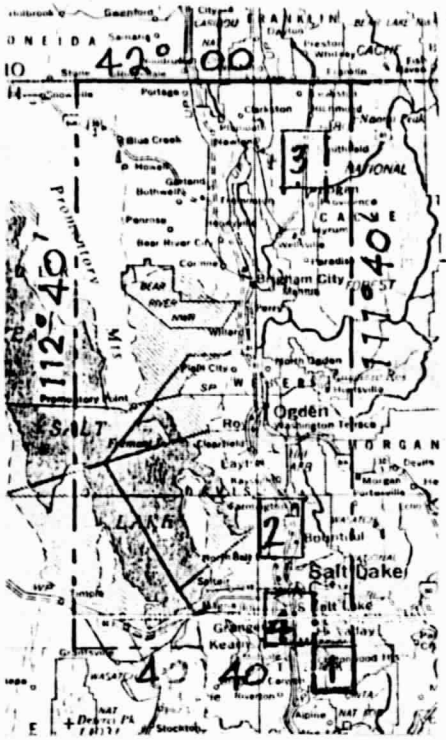
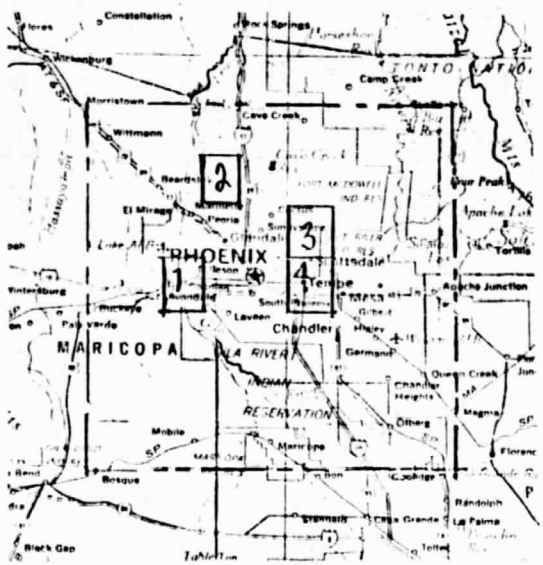
1. Questa. Mining, grass, range, forest.
2. Taos. Urban, irrigated, agriculture, grass, range.
3. Espanola. Mixed type agriculture.
4. Santa Fe. Urban, range, recreation.

NEW MEXICO TEST SITE AND QUADRANGLES



UTAH
TEST AREA AND QUADRANGLES

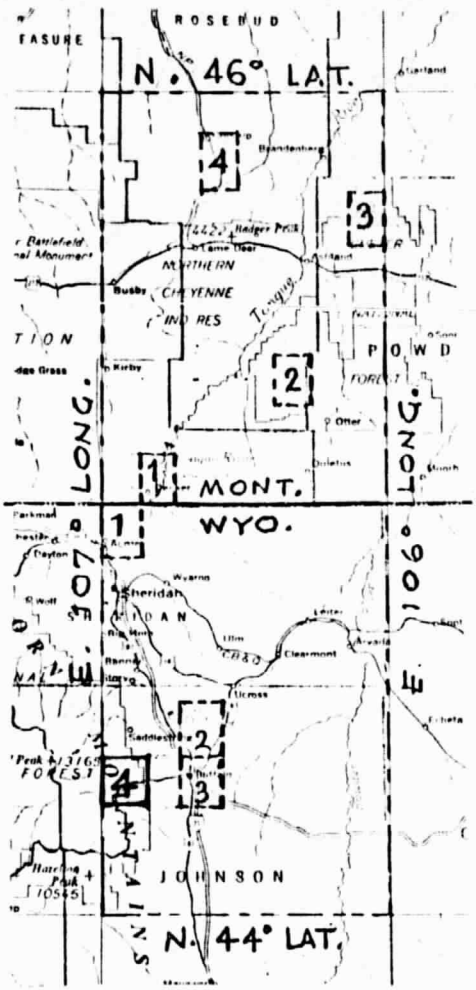
1. Dromedary Peak. High mountains, forest types, bare soil, rock, streams and ponds.
2. Farmington. Urban, range, farming, fluctuating water.
3. Tremonton Quad. Agriculture types.
4. Salt Lake City S. Urban, agriculture.



1. Tolleson quad. Urban, irrigated agriculture, range.
2. Hedgepeth Hills. Irrigated agriculture, range, subdivision.
3. Paradise Valley. Urban, irrigated agriculture, range, recreation.
4. Tempe. Urban, irrigated agriculture, range.

ARIZONA TEST AREA AND QUADRANGLES

MONTANA TEST SITE AND QUADRANGLES



1. Decker quad. Dry grass, coal stripping.
2. Poker Jim Butte. Forest service, grass and ponderosa development.
3. Beaver Creek School. Agriculture, grass, ponderosa.
4. Colstrip. Coal stripping, sub-irrigated agriculture, rangeland.

1. Acme quad. Coal stripping, grassland, range, urban.
2. Lake de Smet. Coal, grassland, range.
3. Buffalo. Coal, grassland, range.
4. Hunter Mesa. Timber and grazing.

WYOMING TEST SITE AND QUADRANGLES

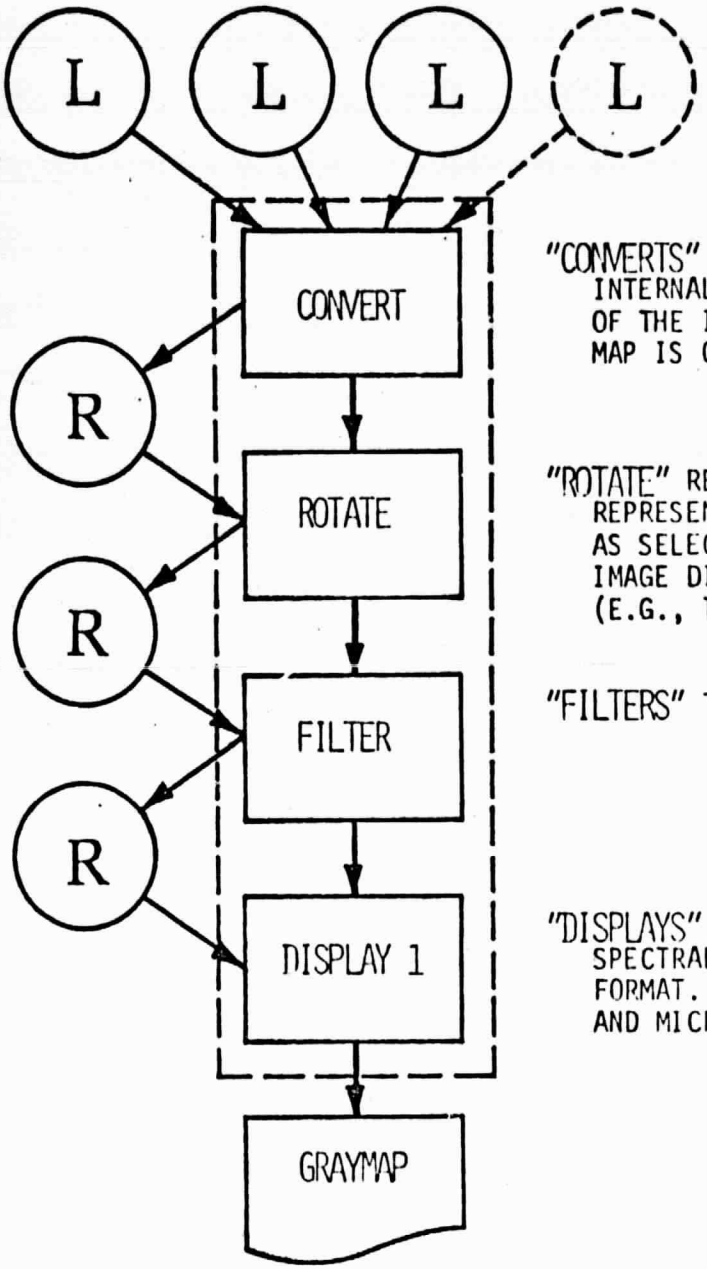
NEW TECHNOLOGY

During this quarter, much work has been done by Colorado State University, the technical subcontractor, in streamlining the processing of computer compatible tapes. While the original pattern recognition program, RECOG, was based on the Larsys and Erim programs, it required too many separate phases of processing for a "production program" in extensive and repeated surveys, under Western circumstances. The result is the Landsat Mapping System (LMS), which is a third generation system and is "map oriented."

This system is a total rewriting of the RECOG (RECOGnition Mapping System). This new system is compatible with RECOG, which was designed principally for training purposes. However, the new design is for specific use with LANDSAT imagery, for map and composite mapping system (CMS) overlay, low cost, ease in understanding, flexibility, export to other user computers, and high volume production.

The following four diagrams illustrate the system functions and the fifth, approximate computer processing costs.

STEP 1. IMAGE PREPARATION/MAP OVERLAY.



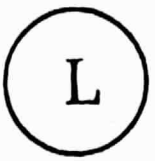
UP TO 4 TAPES, REPRESENTING ~25 MILE E-W SEGMENTS OF A GIVEN LANDSAT IMAGE, MAY BE INPUT SIMULTANEOUSLY.

"CONVERTS" THE LANDSAT FORMAT TAPE(S) INTO THE INTERNAL, SINGLE RECOG TAPE. ONLY THE PORTION OF THE IMAGE NEEDED TO OVERLAY THE SELECTED MAP IS CONVERTED AND POOLED TOGETHER.

"ROTATE" RESAMPLES THE ORIGINAL IMAGE CELLS TO REPRESENT ANY SIZE RECTANGULAR OR SQUARE CELL AS SELECTED BY THE USER. ADJUSTS FOR ORIGINAL IMAGE DISTORTS. SCALES IMAGE TO MAP SCALE (E.G., 1:24,000).

"FILTERS" THE IMAGE.

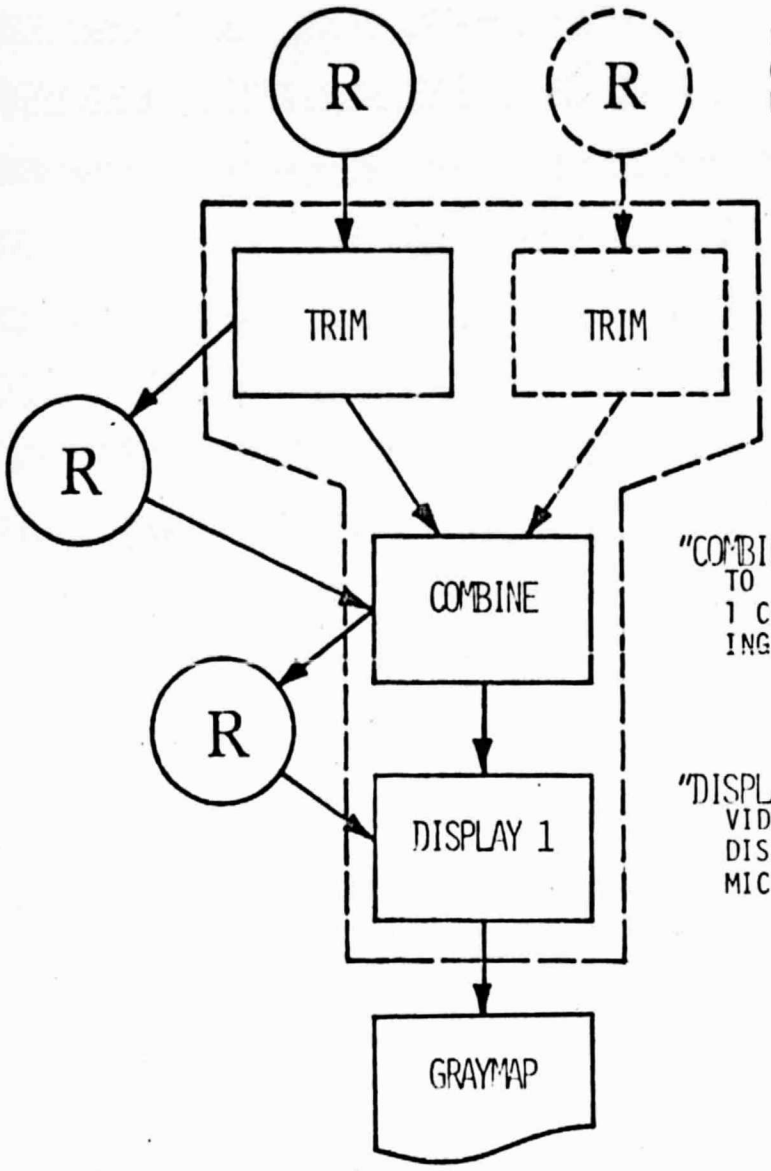
"DISPLAYS" 1, 2, 3 ... OR ALL OF THE INDIVIDUAL SPECTRAL BANDS IN THE ORIGINAL OR MAP OVERLAY FORMAT. DISPLAY OPTIONS INCLUDE LINEPRINTER AND MICROFILM GRAYMAPS.



"LANDSAT" COMPUTER COMPATIBLE TAPE (CCT) AS SUPPLIED BY EROS DATA CENTER.

"RECOG" FORMATTED TAPE (OR DISK) FILE - AS STANDARD FORMAT TAPE USED THROUGHOUT THE IMAGE PROCESSING ACTIVITY.

STEP 2. INTERLEAVES IMAGES FROM VARIOUS DATES.



UP TO 10 RECOG FORMATTED TAPES OF A VARYING NUMBER OF SPECTRAL BANDS ARE INPUT.

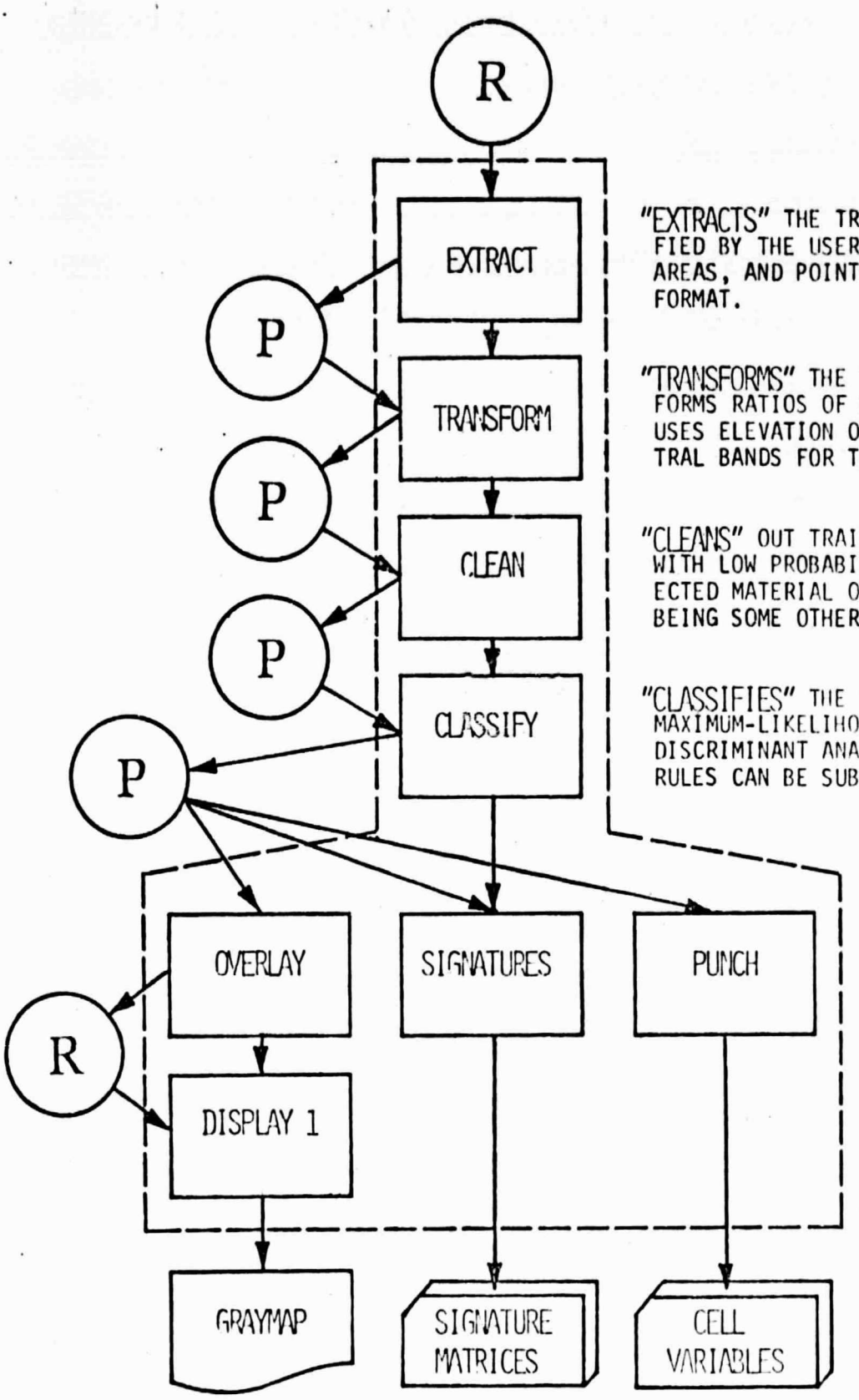
"TRIMS" EACH RECOG FORMATTED TAPE (OR FILE) TO A SELECTED NUMBER OF LINES AND COLUMNS DESIGNATED BY THE USER, USUALLY THOSE NEEDED TO COVER MAP SELECTED. LINES AND COLUMNS ARE RENUMBERED, BEGINNING AT 1,1.

"COMBINES" RECOG FORMATTED DATA FROM THE 1 TO 10 SEPARATE INPUT TAPES (FILES) INTO 1 COMPOSITE RECOG TAPE (FILE) REPRESENTING A MULTIDATE, MULTISPECTRAL IMAGE.

"DISPLAYS" 1, 2, 3 ... OR ALL OF THE INDIVIDUAL SPECTRAL BANDS IN COMBINED IMAGE. DISPLAY OPTIONS INCLUDE LINEPRINTER AND MICROFILM GRAYMAPS.

THIS STEP ALSO PROVIDES A WAY TO INTRODUCE ANCILLARY DATA. FOR EXAMPLE, SLOPE, ELEVATION, ASPECT, HISTORICAL LAND USE, SOIL TYPE, ETC., CAN BE OVERLAID CELL-BY-CELL ONTO THE MULTIDATE, MULTISPECTRAL IMAGE.

STEP 3. COMPUTES STATISTICAL "SIGNATURES" OF MATERIALS TO BE MAPPED.



"EXTRACTS" THE TRAINING FIELD DATA IDENTIFIED BY THE USER (RECTANGLES, IRREGULAR AREAS, AND POINTS) FROM THE RECOG IMAGE FORMAT.

"TRANSFORMS" THE TRAINING FIELD DATA. FORMS RATIOS OF SPECIFIED SPECTRAL BANDS, USES ELEVATION OVERLAYS TO ADJUST SPECTRAL BANDS FOR TERRAIN SHADOWING, ETC.

"CLEANS" OUT TRAINING FIELD DATA POINTS WITH LOW PROBABILITY OF BEING THE SELECTED MATERIAL OR HIGH PROBABILITY OF BEING SOME OTHER MATERIAL, ETC.

"CLASSIFIES" THE TRAINING FIELDS USING MAXIMUM-LIKELIHOOD APPROACH (STEPWISE DISCRIMINANT ANALYSIS). OTHER DECISION RULES CAN BE SUBSTITUTED HERE.

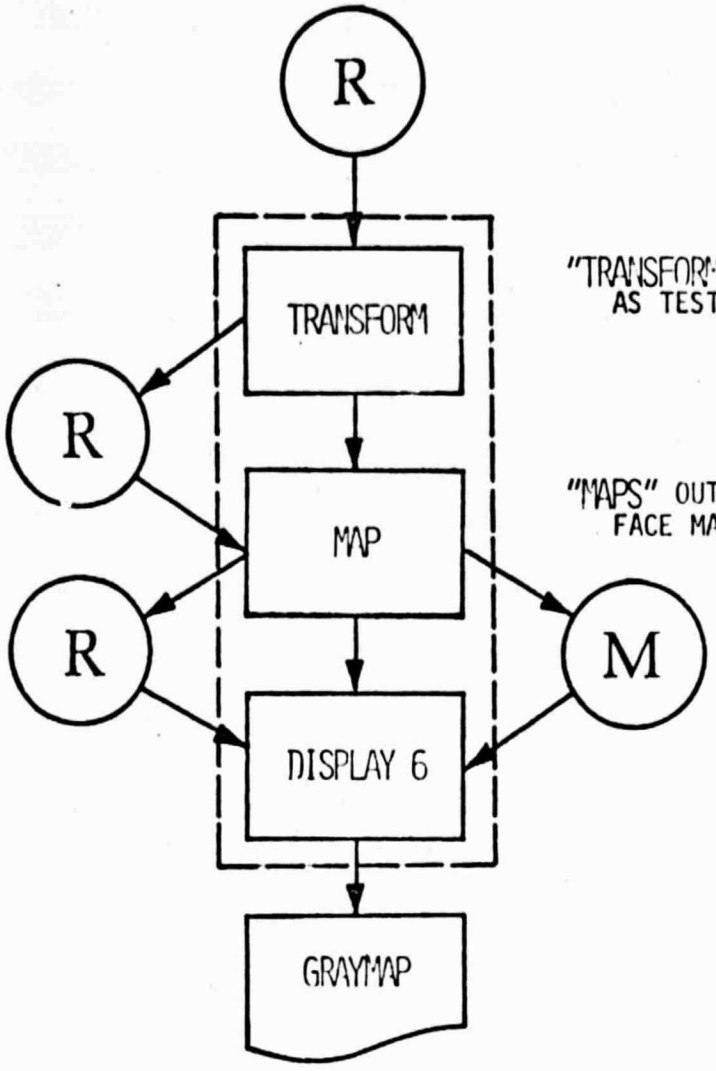
"OVERLAYS" ANY VARIABLE OR RESULT IN POINT FILE INTO A RECOG FORMAT FOR DISPLAY AND MAP OVERLAY.

"SIGNATURES" COMPUTES STATISTICAL REPRESENTATION OF EACH MATERIAL SPECIFIED BY THE USER FOR USE IN MAPPING THESE MATERIALS ON ANY DATA TAKEN FROM THE SAME ORIGINAL IMAGE.

"PUNCHES" OUT ANY VARIABLE(S) IN THE POINT FILE FOR FURTHER ANALYSIS IN THE PROGRAM WRITTEN BY THE USER.

P — "POINT" BY POINT TAPE (OR DISK) FILE. - AN INTERNAL TAPE, DISK, AND/OR CARD FILE FORMAT WHICH CONTAINS ONLY THE EXTRACTED TRAINING FIELD DATA AND DOES NOT MAINTAIN ITS CORRECT MAP OVERLAY POSITION.

STEP 4. MAPS DISTRIBUTION OF EACH MATERIAL.



"TRANSFORMS" DATA FOR EACH IMAGE CELL AS TESTED AND SELECTED IN STEP 3.

"MAPS" OUT THE DISTRIBUTION OF EACH SURFACE MATERIAL SPECIFIED BY THE USER.

"DISPLAYS" THE SELECTED IDENTIFICATION OF EACH IMAGE CELL AND/OR PROBABILITY THAT IT IS THE MATERIAL DESIGNATED. DISPLAY OPTIONS INCLUDE LINEPRINTER AND MICROFILM GRAYMAPS AND LINEPRINTER COLOR SYMBOL MAPS.

M

"MAP" TAPE (OR DISK) FILE. - A DISPLAY TAPE CONTAINING THE IDENTITY OF EACH IMAGE CELL IN THE FINAL MAP OVERLAY AND THE PROBABILITY THAT IT IS CORRECT. THIS TAPE CAN BE USED ON OTHER DISPLAY DEVICES IF PROPERLY FORMATTED OR AS INPUT TO A CELLULAR OR COMPOSITE MAPPING SYSTEM.

ESTIMATED COSTS
LANDSAT MAPPING SYSTEM (LMS)

ITEM	DEVELOPMENT STATUS		COST ESTIMATE*
CONVERT	95%		$5/date
ROTATE	100%		$7/date
FILTER	95%		$6/date
DISPLAY 1	100%	$1/band/date x 2 bands =	$2/date
STEP 1	95%		$20/date
Assuming 3 dates involved gives $20/date x 3 =			$60
TRIM	100%		$3/date
COMBINE	100%	3 dates combined =	$negligible
DISPLAY 1	100%	$1/band/date x 1 band =	$1
STEP 2	not yet integrated		
Assuming 3 dates gives $3/date x 3 dates + $1 =			$10
EXTRACT	90%		$10 (approx.)
TRANSFORM	preliminary version available		$5 (approx.)
CLEAN	preliminary version available		
		$2/iteration x 3 iterations =	$6 (approx.)
CLASSIFY	100%	$8/iteration x 3 iterations =	$24 (approx.)
OVERLAY	designed only		? and optional
SIGNATURES	90%		$2 (approx.)
PUNCH	designed only		? and optional
STEP 3	40%		
Based on 2,000 points =			$50 (approx.)
TRANSFORM	0%		$5 (approx.)
MAP	90%	based on mapping 30 material types	$70 (approx.)
DISPLAY 6	90%	black-&-white lineprinter symbol map	$5 (approx.)
STEP 4	75%		
Based on 30 classes mapped =			$80 (approx.)
		STEP TOTAL* =	$200 (approx.)

* Estimated computer costs for 1 of 1:24,000 quad map with:
~1 acre cells
3 dates (12 spectral bands)
2,000 cells defining training fields
30 material types
black-&-white lineprinter display

PROGRAM OF NEXT REPORTING INTERVAL

During the winter and spring of 1976, the lead agencies will specify, with their state user groups, typical area planning problems for additional data collection and multi-source computer mapping analyses. By this time, the CMS-II cellular mapping program will be available to fit any state computer installation. Also, Los Alamos will have compatible and efficient high-speed scanning and analysis procedures for conventional map and non-satellite remote sensing. This phase will demonstrate to potential users the versatility of a state information system for land use and related data.

On January 13 and 14, a project review session will be held with project participants, the Federation's project advisory committee: the Earth Resources Technology Advisory Committee, and other interested persons from the region.

Specific activities proposed for the next few months include:

1. CSU will be producting first-round Landsat generated land use maps and sending them to the states for verification. They will also develop a standard verification procedure.

2. The Federation will be reporting on project progress to the states and will be working with them on formulating relevant compositing problems.

3. The state lead agencies will be verifying CSU's land use outputs, filling ground truth data gaps, initiating data collection and problem plans for further compositing and analysis, and continuing work with interested user groups.

4. Los Alamos will continue on software development and hardware testing for computer map compositing and analysis.

5. Another meeting of participants is planned to review the land use outputs and verification, to discuss compositing problems and format, and to begin final report design.

CONCLUSIONS

A. The quality of the U-2 color infrared photography was so poor that it was, in most cases, unsuitable for use. Some flight lines were off and many images were "burned out" and of poor quality. Since this material took so long to be obtained and was then not useable, the state lead agencies generally relied upon other data for use in ground truth and test site work.

B. The project is close to schedule, being about one month behind in obtaining first round land use maps. This will be brought up to date in the next quarter. A review meeting will be held January 13, 14, 1976.

C. Interagency participation in data collection assistance is picking up in various states. Additional efforts will be needed by lead agencies to involve them in the next step of multi-source computer mapping and analysis.

D. It has become apparent in the field work on the training sites that a thorough "Manual for Training Site Specification" is needed, particularly for extensive area applications of Landsat data. This should cover such topics as: land cover reflectance interpretation, seasonal and mixed cover description, appropriate map and tabular data forms, evaluation of the signature accuracy and follow-up verification and ground work.

E. The new technology of the CCT pattern recognition program called Landsat Mapping System (LMS) will speed up working applications, reduce machine processing and appeal to users from other fields. Land use maps will soon be available to the state lead agencies.

F. The new CMS-II program provides a versatile input chamber for map filing and quantitative manipulation of regional data of various sources and forms and will be made available to interested users.

RECOMMENDATIONS

A. Regarding the problem with the U-2 coverage, it is too late to re-fly the test areas and provide any useful data for work on this project. Perhaps the project could recover the $1,080 earmarked for this coverage and utilize it for more productive efforts; for example, for final report publication costs for dissemination to a wider user clientele.

B. Referring to increased interagency cooperation, the lead agencies have completed the "measurement work" of specification and ground truth for Landsat calibration, but the next phase will be much more in the nature of "applications." The various agencies of the states can logically carry much more project responsibility in such steps as defining and conducting composite mapping analyses and solutions to resource problems in the quadrangles, or ultimately joining in a state mapping bank and incorporating the Landsat project technology. This is all becoming timely, and will be featured in the next regional meeting during this quarter. Further, lead agencies in each state should be assembling an interagency project group made up of individuals with interest in this new process. The establishment of annual technical and applications seminars could help to encourage continuous interagency applications.

C. A manual for the selection and survey of training sites and later verification of Landsat maps should be developed, including forms, procedures for handling mixed and ambiguous land use categories, and cross-references to the Landsat Data Users' Handbook. This is apparent in an extensive geographic project, and particularly when attempting to cover seasonal changes. This is a much needed follow-on project for encouraging wide-spread applications.

APPENDIX A

ORIGINAL PROJECT WORK SCHEDULE AND CALENDAR

State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
DATA PROCUREMENT AND DATA PREPARATION					
		(I.A) Convene all participants for review & training sessions. Throughout the project: - provide quarterly reports to NASA, states - review progress - fiscal control - coordinate makeup plans - state, CSU and LASL coordination in technical work - technical assistance to states in establishing wider survey system	(I.A) Review and training	(I.A) Participate in the initial training session	(I.A) Preside and participate in the first general review meeting. (Throughout the project provide review and advice for scientific and policy matters.)
			(I.B) Define the preferred land use classification system in 1st & 2nd order, adapt to test areas & the state planning & analytic purposes of a data system		

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(I.C) Procure maps, air photos, high altitude data for test sites					
	(I.D) Procure remote sensing imagery of test sites for series of dates				
	(I.E) Determine map control points for sites for geometric rectification of remote sensing imagery				
	(I.F) Rectify appropriate portions of each original ERTS-computer compatible tape (CCT) to conform to I.E				
(I.G) Select land use identification sites (jointly)			(I.G) Select most significant land use classes for training sites, for computer image processing		

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				(I.H) Consultation and assistance on rectification procedures	
	(I.I) Combine rectified ERTS-CCT onto a single tape for each site: 1. continuous segments of each site from rectified images 2. each spectral band from each date will be interleaved				
		(I.J) Work with CSU and LASL to integrate cellular system for wider scope data files & compositing analysis		(I.J) Work with FRMS & CSU to set up a demonstration of a cellular interchangeable mapping system for a wider scope of information, accepting any raw data form	(I.J) Advise on purposes & characteristics of a regional cellular mapping syster

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LAND USE CLASS IDENTIFICATION PROCEDURES					
(II.A) Provide available information on geology, soil, topography, etc., for study of effects on land use identification by remote sensing, for II.C	(II.B) Statisically analyze & characterize land use readings, in order to: 1. recognize erroneous data in the training fields 2. determine clear separations between classes (II.C) Analyze effects of extraneous variables (i.e., geology, soils, slope, etc.,) on interpretation of land use classes	(II.D) Convene all participants for stage agreements	(II.E) Determine most practical cell sizes for the several purposes of the project & future system applications, develop the LASL approach to multi-factor mapping	(II.F) Determine scope of socio-economic or resource topics for analytic mapping, beyond the ERTS land use range. Determine best sources & needed state inputs.	(II.G) Review meeting #2
(II.G) Field or photo-check anomolous portions of training sites (those statistically inconsistent from CSU analysis -Task II.B & II.C)	(II.H.) Analyze & correct the remote sensing readings for new modified land use classes		(II.I. Modify training sites & land use classes as needed before final review of land use identification		

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LAND USE MAPPING IN THE TARGET QUADRANGLES					
(III.A) Select four 7 1/2 minute quadrangle map areas within the test sites in each state for detailed ERTS mapping	(III.B) Aggregate the ERTS picture elements into larger cell sizes (i.e., 10 or 40 acres) as jointly determined	(III.H) Convene all participants for stage agreements	(III.H) Review output products	(III.C) Consultation and assistance on cell aggregation procedures, appropriate for the test data file extending beyond ERTS land use classes.	(III.H) Review meeting #3
(III.D) Collect additional needed and/or desired data for the quadrangles for verification & analysis purposes as well as cost/time information on data preparation	(III.E) Identify land uses in all cells in the selected map quadrangle areas			(III.I) Obtain ERTS land use outputs and other state inputs for demonstration of "mixed" data analysis & composite mapping for states' selected planning objectives	
(III.G) Evaluate the accuracy of the land use overlays prepared from the ERTS source	(III.F) Prepare transparent computer land use classification overlays of the selected quadrangles				

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TECHNOLOGICAL ASSESSMENT OF RESULTS, AND COMPARATIVE EFFICIENCY AND COSTS					
(IV.A) Provide further analysis requirements	(IV.B) Examination and assessment of classification errors (IV.D Comparison of ERTS land use classifications with other methods (IV.E) Provide cost/information tradeoff analysis (IV.G) Identify needed R & D and future capabilities of ERTS land use information	(IV.C) Aid states and LASL in further analysis possibilities	(IV.H) Evaluate ERTS land use survey system and its contribution to general area analysis relative to the LASL demonstration	(IV.F) Produce composite mapping simulations & analysis as per state guidelines	(IV.H) Evaluate ERTS land use survey system and its contribution to general area analysis relative to the LASL demonstration

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PREPARATION OF FINAL PRODUCTS					
(V.A) Prepare any additional input for final report	(V.B) Prepare final forms of computer images and printed overlays. Draft Technical Report & Users Report on ERTS applications			V.C) Prepare final output & contribute to the general report on techniques and results	
		(V.D) Convene participants in a final evaluation and procedure workshop	(V.D) Review and evaluate products & results - review draft of final report - determine further efforts		(V.D) Preside over review meeting and workshop
(V.E) Participate in general report	(V.E) Participate in General Report	(V.E) Coordinate the preparation of the General Report on both ERTS & larger scope data system including the socio-economic and resource mapping of LASL			

Fig. 5. TIME SEQUENCE - page 1 of 3

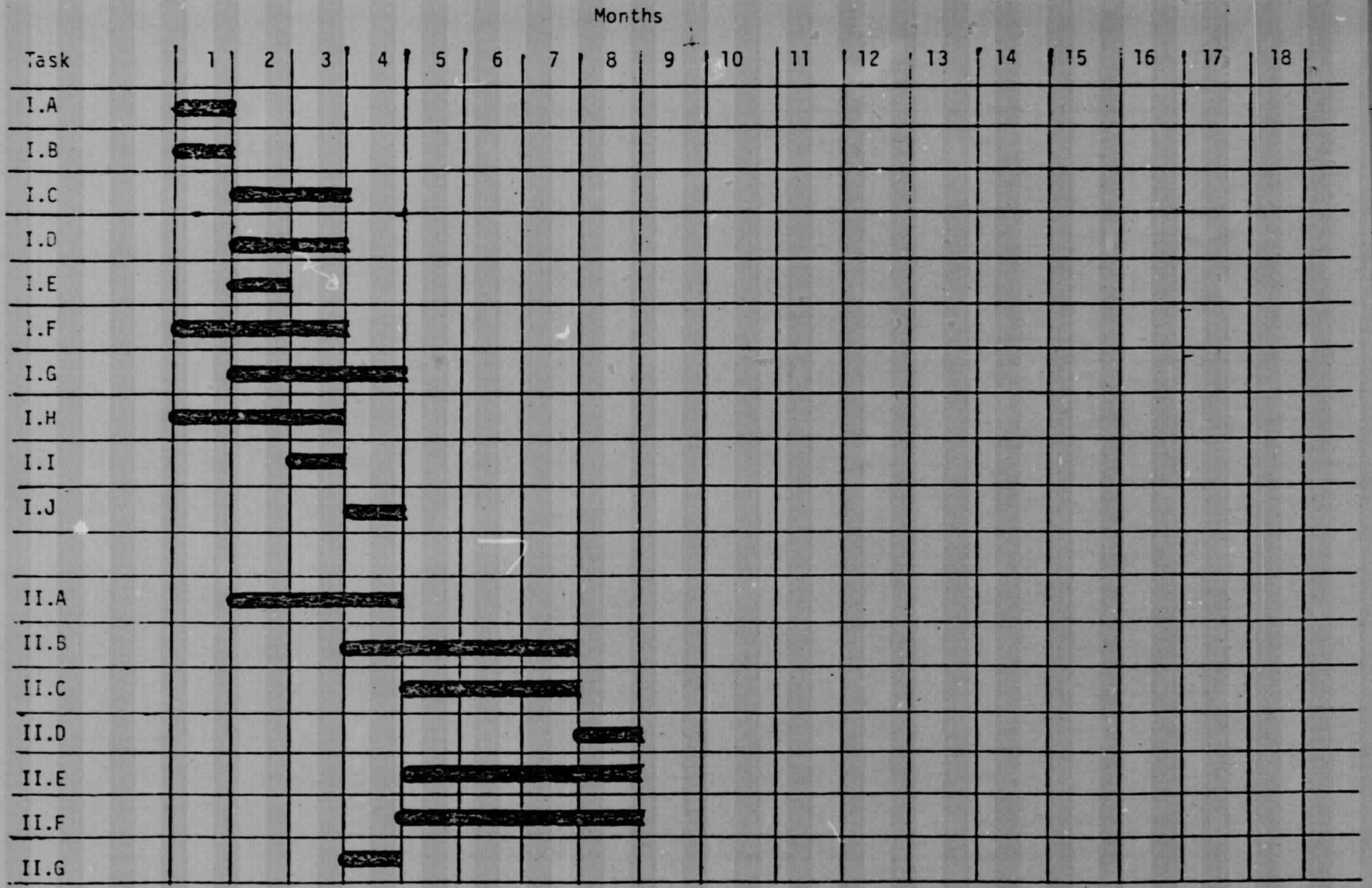

Fig. 5. TIME SEQUENCE - page 2 of 3

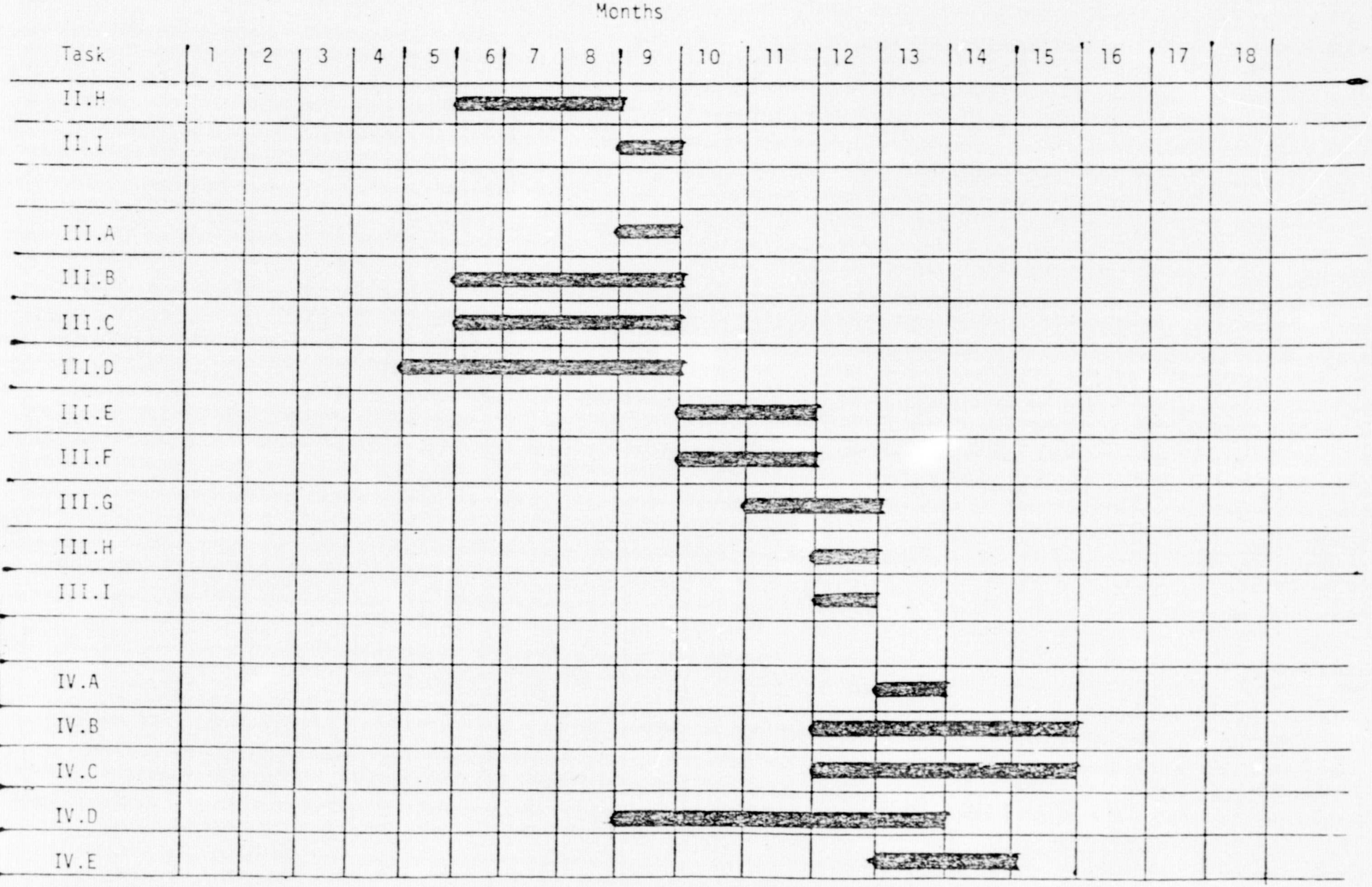

Fig. 5. TIME SEQUENCE - page 3 of 3